INVENTION: Decisioning rules for turbo and convolutional decoding

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WHAT IS CLAIMED IS:

1. A means for the new turbo decoding a-posteriori probability p(s,s'|y) in equations (13) of the invention disclosure of the decoder trellis states s',s for the received codeword k-1,k conditioned on the received symbol set y = {y(1),y(2),. . .,y(k-1),y(k),. . .,y(N)} for defining the maximum a-posteriori probability MAP in turbo decoding and which

provide a new statistical definition of the MAP logarithm likelihood ratio L(d(k)|y) in equations (18) in the invention disclosure equal to the natural logarithm of the ratio of the a-posteriori probability p(s,s'|y) summed over all state transitions s'→s corresponding to the transmitted data d(k)=1 to the p(s,s'|y) summed over all state transitions s'→s corresponding to the transmitted data d(k)=0

provide a means for a factorization of the a-posteriori p(s,s'|y) into the product of the a-posteriori probabilities p(s'|y(j<k)), p(s|s',y(k)), p(s|y(j>k))

provide a means for the turbo decoding forward recursion equation for evaluating the a-posteriori probability p(s'|y(j<k)) using p(s|s',y(k)) as the state transition a-posteriori probability of the trellis transition path s'→s to the new state s at k from the previous state s' at k-1 and given the observed symbol y(k) to update these recursions for the assumed value of d(k) equivalent to the transmitted symbol x(k) which is the modulated symbol corresponding to d(k)

provide a means for the turbo decoding backward recursion equation for evaluating the a-posterior probability p(s|y(j>k)) using p(s'|s,y(k)) as the state transition a-priori probability of the trellis transition path s→s' to the new state s' at k-1 from the previous state s at k and the observed symbol y(k) to

update these recursions for the assumed value of d(k) equivalent to the transmitted symbol x(k) which is the modulated symbol corresponding to d(k) and where $p(s'|s,y(k))=p(s|s',y(k))$

provide a means for evaluating the natural logarithm of the state transition a-posteriori probability $p(s|s',y(k))= p(s'|s,y(k))$ as a function which is linear in the received symbol y(k)

provide a means for evaluating the natural logarithm of the state transition a-posteriori probability $p(s'|s,y(k)) = p(s|s',y(k))$ equal to the sum of the new decisioning metric DX in equations (11),(16) in the invention disclosure and the natural logarithm of the a-priori probability p(d(k)) equal to

$$\begin{aligned}\ln[p(s|s',y(k))] &= \ln[p(s'|s,y(k))] \\ &= DX + \ln[p(d(k))]\end{aligned}$$

$$DX = \operatorname{Re}[y(k)x^*(k)]/\sigma^2 + |x(k)|^2/2\sigma^2$$

in which ln[(o)] is the natural logarithm of (o) and $x^*(k)$ is the complex conjugate of x(x) and the new decisioning metric DX is linear in y(k)

provide a means for the state transition probabilities in the MAP equations to use the new decisioning metric DX in equations (11),(16) in the invention disclosure $DX = \operatorname{Re}[y(k)x^*(k)]/\sigma^2 + |x(k)|^2/2\sigma^2$ in place of the current use of the maximum likelihood decisioning metric equal to $[\ -|y(k) - x(k)|^2/2\sigma^2\ ]$

provide a means for the natural logarithm of the state transition probability in the turbo decoding equations to be a linear function of y(k) in place of the current quadratic function of y(k)

provide a means for the MAP turbo decoding algorithms to realize some of the performance improvements demonstrated in FIG. 5,6 using the new decisioning metrics in the invention disclosure

provide a means for a new a-posterior mathematical paradym which enables the MAP turbo decoding algorithms to be restructured to allow the natural logarithms of the decisioning

metrics to be linear in the detected symbols in place of the current quadratic dependency on the detected symbols

provide a means for a new a-posteriori mathematical paradym which enables the MAP turbo decoding algorithms to be restructured and to determine the intrinsic information as a function of the new decisioning metrics linear in the detected symbols

2. A means for the new convolutional decoding a-posteriori probability p(s,s'|y) in equations (13) of this invention disclosure, of the decoder trellis states s',s for the received codeword k-1,k conditioned on the received symbol set y = {y(1),y(2),. . .,y(k-1),y(k),. . .,y(N)} for defining the state transition metrics in the forward and backward recursive equations for convolutional decoding and which

provide a means for the new maximum a-posteriori probability f(x|y) of the transmitted symbol x given the received symbol y to replace the current maximum likelihood probability f(y|x) used for convolutional decoding of the received symbol y given the transmitted symbol x

provide a means for the new maximum a-posteriori principle which maximizes f(x|y) with respect to the transmitted symbol x to replace the current maximum likelihood principle which maximizes f(y|x) with respect to the transmitted symbol x for deriving the forward and the backward recursive equations to implement convolutional decoding, and in which f(x|y) is the a-posteriori probability of the transmitted symbol x given the observed symbol y and in which f(y|x) is the likelihood funcion which is the probability of the observed symbol y given the transmitted symbol x

provide a means for a factorization of the a-posteriori p(s,s'|y) into the product of the a-posteriori probabilities p(s'|y(j<k)), p(s|s',y(k)), p(s|y(j>k))

provide a means for the convolutional decoding forward recursion equation for evaluating the a-posteriori probability p(s|y(j<k),y(k)) using p(s|s',y(k)) as the state transition

probability of the trellis transition path $s'\rightarrow s$ to the new state s at k from the previous state s' at k-1 and given the observed symbol y(k) to update these recursions for the assumed value of d(k) equivalent to the assumed value for x(k) corresponding to d(k)

provide a means for the convolutional decoding backward recursion equation for evaluating the a-posteriori probability $p(s|y(j>k))$ using $p(s'|s,y(k))$ as the state transition probability of the trellis transition path $s\rightarrow s'$ to the new state s' at k-1 from the previous state s at k and given the observed symbol y(k) to update these recursions for the assumed value of d(k) equivalent to the assumed value for x(k) corresponding to d(k)

provide a means for evaluating the natural logarithm of the state transition a-posteriori probabilities $\ln[p(s'|s,y(k))]=\ln[p(s|s',y(k))]$, as a function which is linear in the received symbol y(k)

provide a means for evaluating the natural logarithm of the state transition a-posteriori probabilities $\ln[p(s'|s,y(k))]=\ln[p(s|s',y(k))]$ equal to the sum of the new decisioning metric DX in equations (11),(16) in the invention disclosure and the natural logarithm of the a-priori probability p(d(k)) equal to

$$\ln[p(s'|s,y(k))] = \ln[p(s'|s,y(k))]$$
$$= DX + \ln[p(d(k))]$$

$$DX = \mathrm{Re}[y(k)x^*(k)]/\sigma^2 + |x(k)|^2/2\sigma^2$$

in which $\ln[(o)]$ is the natural logarithm of (o) and $x^*(k)$ is the complex conjugate of x(x) and the new decisioning metric DX is linear in y(k)

provide a means for the state transition probabilities in the convolutional decoding equations to use the new decisioning metric $DX=\mathrm{Re}[y(k)x^*(k)]/\sigma^2+|x(k)|^2/2\sigma^2$ in equations (11),(16) in the invention disclosure in place of the current use of the maximum likelihood decisioning metric equal to $[\ -|y(k)-x(k)|^2/2\sigma^2\ ]$

provide a means for the natural logarithm of the state transition probability in the convolutional decoding equations to be a linear function of y(k) in place of the current quadratic function of y(k)

provide a means for the convolutional decoding algorithms to realize some of the performance improvements demonstrated in FIG. 5,6 using the new decisioning metrics in this invention disclosure

provide a means for a new a-posteriori mathematical paradym which enables the convolutional decoding algorithms to be restructured to allow the natural logarithms of the decisioning metrics to be linear in the detected symbols

3. A means for the new a-posteriori probability $p(s,s'|y)$ in equations (13) of the invention disclosure of the decoder trellis states s',s for the received codeword k-1,k conditioned on the received symbol set $y = \{y(1),y(2),\ldots,y(k-1),y(k),\ldots,y(N)\}$ for replacing the current probability $p(s,s',y)$ for turbo decoding and for convolutional decoding when the natural logarithm of the a-priori probability is set equal to zero meaning $\ln[p(d)]=\ln[p(x)]=0$ and which

provide a means for a factorization of the a-posteriori probability $p(s,s'|y)$ into the product of the a-posteriori probabilities a_{k-1}, b_k, p_k defined in equations (13) in the invention disclosure

$$a_{k-1} = p(s'|y(j<k))$$

$$b_k = p(s|y(j>k))$$

$$p_k = p(s|s',y(k))$$

and the natural logarithms are $\underline{a}_{k-1}=\ln[a_{k-1}]$, $\underline{b}_k=\ln[b_k]$, $\underline{p}_k=\ln[p_k]$ and replacing the current factorization of $p(s,s',y)$ into the product of the α_{k-1}, β_k, γ_k in equations (3) in the background art

$$\alpha_{k-1}(s') = p(s',y(j<k))$$

$$\beta_k(s) = p(y(j>k)|s)$$

$$\gamma_k(s,s') = p(s,y(k)|s')$$

and the natural logarithms are $\underline{\alpha}_{k-1}=\ln[\alpha_{k-1}]$, $\underline{\beta}_k=\ln[\beta_k]$, $\underline{\gamma}_k=\ln[\gamma_k]$

provide a means for the forward recursion equation for evaluating $\underline{a}_k$ using $\underline{p}_k = \ln[p(s|s',y(k))]$ as the natural logarithm of the state transition a-posteriori probability of the trellis transition path $s' \rightarrow s$ to the new state s at k from the previous state s' at k-1 and given the observed symbol y(k) to update these recursions for the assumed value of d(k) equivalent to the transmitted symbol x(k) which is the modulated symbol corresponding to d(k) and replacing the current forward recursive equation for evaluating the forward recursion equation for $\underline{\alpha}_k$ using $\gamma_k(s,s') = \ln[p(s,y(k)|s')]$ as the natural logarithm of the state transition probability of the trellis transition path $s' \rightarrow s$ to the new state s at k from the previous state s' at k-1 and the probability of the observed symbol y(k).

provide a means for the backward recursion equation for evaluating $\underline{b}_k$ using $\underline{p}_k = \ln[p(s'|s,y(k))] = \ln[p(s|s',y(k))]$ as the natural logarithm of the state transition a-posteriori probability of the trellis transition path $s \rightarrow s'$ to the new state s' at k-1 from the previous state s at k and given the observed symbol y(k) to update these recursions for the assumed value of d(k) equivalent to the transmitted symbol x(k) which is the modulated symbol corresponding to d(k) and replacing the current forward recursive equation for evaluating the forward recursion equation for $\underline{\beta}_k$ using $\gamma_k(s,s') = \ln[p(s,y(k)|s')]$ as the natural logarithm of the state transition probability of the trellis transition path $s' \rightarrow s$ to the new state s at k from the previous state s' at k-1 and the probability of the observed symbol y(k)

provide a means for evaluating the natural logarithm of the state transition a-posteriori probability $p(s|s',y(k)) = p(s'|s,y(k))$ as a function which is linear in the received symbol y(k)

provide a means for evaluating the natural logarithm of the state transition a-posteriori probability $\underline{p}_k$ equal to the sum of the new decisioning metric DX in equations (11),(16) in the

invention disclosure and the natural logarithm of the a-priori probability p(d(k)) equal to

$$\underline{p}_k = DX + \ln[p(d(k))]$$

$$DX = \mathrm{Re}[y(k)x^*(k)]/\sigma^2 + |x(k)|^2/2\sigma^2$$

and replacing the current natural logarithm of the state transition probability γ_k equal to the sum of the current decisioning metric DM in equations (1),(6) in the background art

$$\gamma_k = DM + \ln[p(d(k))]$$

$$DM = -|y(k)-x(k)|^2/2\sigma^2$$

and our new decisioning metric DX is linearly proportional to y(k) and the current decisioning metric DM is a quadratic function of y(k)

provide a means for the natural logarithm of the state transition probability in the turbo and convolutional decoding equations to be a linear function of y(k) in place of the current quadratic function of y(k)

provide a means for the decoding algorithms to realize some of the performance improvements demonstrated in FIG. 5,6 using the new decisioning metrics in this invention disclosure

provide a means for a new a-posteriori mathematical paradym which enables the decoding algorithms to be restructured to allow the natural logarithms of the decisioning metrics to be linear in the detected symbols